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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor name(s): Michael B. Ball
(identify the full name of each inventor)

Invention title: FLIP CHIP AND CONVENTIONAL STACK

UTILITY PATENT APPLICATION TRANSMITTAL

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Sir:

Enclosed for filing in connection with the above-identified utility patent application, and submitted in the order listed, are:

- ☒ Postcard receipt acknowledgment (attached to the front of this transmittal).
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- ☒ Check no. 6783 in the amount of \$1058.00 for the filing fee calculated as follows:

Basic fee	\$750.00
Total claims $34 - 20 = *14 \times 22.00 =$	308.00
Indep. claims $2 - 3 = *0 \times 78.00 =$	0
One or more multiple dependent claims (+250.00)	0
SUBTOTAL (basic fee plus extra claims fees)	1058.00
Reduction for small entity - 50% of subtotal†	
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- ☐ Verified statement(s) to establish small entity status under 37 C.F.R. § 1.9 and § 1.27 signed by (or on behalf of)
- ☒ Assignment recordation form (with assignment and recording fee).
- ☒ Specification including title page, claims and single page abstract consisting of 19 total pages.
- ☒ Declaration for patent application (with power of attorney) affixed to the specification after the abstract.
- ☒ Copies of ☐ formal ☒ informal drawings consisting of 4 sheets (5 total figures).
- ☐ Information Disclosure Statement.
- ☐ Form-1449 with copies of listed documents.

Remarks:

- ☐ Priority under 35 U.S.C. § 119 is claimed with respect to foreign application serial no. filed in on .
- ☐ This application is being filed without a declaration.
- ☐ This is a continuation-in-part application of prior US application serial no. filed .
- ☒ The commissioner is authorized to charge any additional fees required but not submitted with any document or request requiring fee payment under 37 C.F.R. § 1.16 and § 1.17 to deposit account no. 20-1469 during the entire pendency of this application. Please address all communications to the address identified below.

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APPLICATION FOR LETTERS PATENT

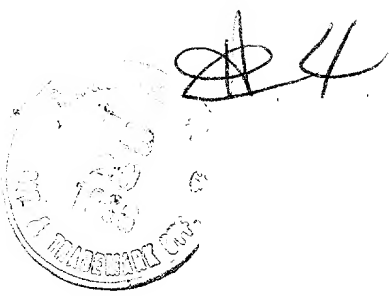
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FLIP CHIP AND CONVENTIONAL STACK

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FLIP CHIP AND CONVENTIONAL STACK

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BACKGROUND OF THE INVENTION

5 Field of the Invention: The present invention relates to an apparatus and a method for increasing semiconductor device density. In particular, the present invention relates to a vertical multi-chip device using combined flip chip and wire bond assembly techniques to achieve densely packaged semiconductor devices, and a method for producing such devices.

10 State of the Art: Definitions: The following terms and acronyms will be used throughout the application and are defined as follows:

15 BGA - Ball Grid Array: An array of minute solder balls ^{disposed} ~~deposited~~ on an attachment surface of a semiconductor die wherein the solder balls are refluxed for simultaneous attachment and electrical communication of the semiconductor die to a printed circuit board.

20 COB - Chip On Board: The techniques used to attach semiconductor ^{die} ~~die~~ to a printed circuit board, including flip chip attachment, wirebonding, and tape automated bonding ("TAB").

25 Flip Chip: A chip or die that has a pattern or array of terminations spaced around the active surface of the die for face down mounting of the die to a substrate.

30 Flip Chip Attachment: A method of attaching a semiconductor die to a substrate in which the die is inverted so that the connecting conductor pads on the face of the device are set on mirror-image pads on the substrate (such as a printed circuit board), and bonded by solder reflux or a conductive polymer curing.

35 Glob Top: A glob of encapsulant material (usually epoxy or silicone or a combination thereof) surrounding a semiconductor die in a COB assembly.

40 PGA - Pin Grid Array: An array of small pins extending substantially perpendicularly from the major plane of a semiconductor die, wherein the pins conform to a specific arrangement on a printed circuit board or other substrate for attachment thereto.

SLICC - Slightly Larger than Integrated Circuit Carrier: An array of minute solder balls disposed on an attachment surface of a semiconductor die similar to a BGA, but having a smaller solder ball pitch and diameter than a BGA.

* * * * *

State-of-the-art COB technology generally consists of three semiconductor die to printed circuit board conductive attachment techniques: flip chip attachment, wirebonding, and TAB.

Flip chip attachment consists of attaching a semiconductor die, generally having a BGA, ^{an} SLICC or a PGA, to a printed circuit board. With the BGA or SLICC, the solder or other conductive ball arrangement on the semiconductor die must be a mirror-image of the connecting bond pads on the printed circuit board such that precise connection is made. The semiconductor die is bonded to the printed circuit board by refluxing the solder balls. With the PGA, the pin arrangement of the semiconductor die must be a mirror-image of the pin recesses on the printed circuit board. After insertion, the semiconductor die is generally bonded by soldering the pins into place. An under-fill encapsulant is generally disposed between the semiconductor die and the printed circuit board for environmental protection and to enhance the attachment of the die to the board. A variation of the pin-in-recess PGA is a J-lead PGA, wherein the loops of the J's are soldered to pads on the surface of the circuit board. Nonetheless, the lead and pad locations must coincide, as with the other referenced flip-chip techniques.

Wirebonding and TAB attachment generally begins with attaching a semiconductor die to the surface of a printed circuit board with an appropriate adhesive, such as an epoxy. In wirebonding, a plurality of bond wires are attached, one at a time, to each bond pad on the semiconductor die and extend to a corresponding lead or trace end on the printed circuit board. The bond wires are generally attached through one of three industry-standard wirebonding techniques: ultrasonic bonding - using a combination of pressure and ultrasonic vibration bursts to

form a metallurgical cold weld; thermocompression bonding - using a combination of pressure and elevated temperature to form a weld; and thermosonic bonding - using a combination of pressure, elevated temperature, and ultrasonic vibration bursts. The die may be oriented either face up or face down (with its active surface and bond pads either up or down with respect to the circuit board) for wire bonding, although face up orientation is more common¹. With TAB, ends of metal leads carried on an insulating tape such as a polyimide are respectively attached to the bond pads on the semiconductor die and to the lead or trace ends on the printed circuit board. An encapsulant is generally used to cover the bond wires and metal tape leads to prevent contamination.

Higher performance, lower cost, increased miniaturization of components, and greater packaging density of integrated circuits are ongoing goals of the computer industry. Greater integrated circuit density is primarily limited by the space or "real estate" available for mounting die on a substrate such as a printed circuit board. Conventional lead frame design inherently limits package density for a given die size because the die-attach paddle of the lead frame must be larger than the die to which it is bonded. The larger the die, the less space that remains around the periphery of the die-bonding pad for wire bonding. Furthermore, the wire bonding pads on the standard lead frame provide anchorage for the leads when the leads and the die are encapsulated in plastic. Therefore, as the die size is increased in relation to a given package size, there is a corresponding reduction in the space along the sides of the package for the encapsulating plastic which joins the top and bottom of the plastic body at the mold part line and anchors the leads. Thus, as the leads and encapsulant are subjected to the normal stresses of subsequent forming and assembly operations, the encapsulating plastic may crack, compromising package integrity and substantially increasing the probability of premature device failure.

A so-called "leads over chip" (LOC) arrangement eliminates the die-attach paddle of the lead frame and supports the die by its active surface from the inner lead ends of the lead frame. This permits a wider variety of bond pad patterns on the die,

extends the leads-to-encapsulant bond area and, with appropriate design parameters, can reduce the size of the packaged device for a given die size.

One method of increasing integrated circuit density is to stack die vertically. U.S. Patent 5,012,323 ("the '323 patent") issued April 30, 1991 to Farnworth teaches combining a pair of die mounted on opposing sides of a lead frame. An upper, smaller die is back-bonded to the upper surface of the leads of the lead frame via a first adhesively coated, insulated film layer. A lower, larger die is face-bonded to the lower lead frame die-bonding region via a second, adhesively coated, insulative, film layer. The wire-bonding pads on both upper die and lower die are interconnected with the ends of their associated lead extensions with gold or aluminum bond wires. The lower die must be slightly larger than the upper die in order that the die pads are accessible from above through a bonding window in the lead frame such that gold wire connections can be made to the lead extensions. This arrangement has a major disadvantage from a production standpoint, since the different size ^{dice}~~die~~ require that different equipment produce the different die or that the same equipment be switched over in different production runs to produce the different die.

U.S. Patent 5,291,061 issued March 1, 1994 to Ball teaches a multiple stacked die device containing up to four stacked ^{dice}~~die~~ supported on a die-attach paddle of a lead frame, the assembly not exceeding the height of current single die packages, and wherein the bond pads of each die are wirebonded to lead fingers. The low profile of the device is achieved by close-tolerance stacking which is made possible by a low-loop-profile wirebonding operation and thin adhesive layers between the stacked ^{dice}~~die~~.

U.S. Patent 5,323,060 issued June 21, 1994 to Fogal et al. teaches a multichip module that contains stacked die devices, the terminals or bond pads of which are wirebonded to a substrate or to adjacent die devices.

U.S. Patent 5,422,435 to Takiar et al. teaches stacked ^{dice}~~die~~ having wire bonds extending to each other and to the leads of a carrier member such as a lead frame.

U.S. Patent 5,399,898 issued May 21, 1995 to Rostoker ("Rostoker") teaches multichip, multitier semiconductor arrangements based on single and double-sided flip-chips. Rostoker discloses bridging a die over and between two ^{adjacent dice}~~adjacent die~~.

However, Rostoker intuitively requires the die and bond pad bump patterns be specifically designed to achieve proper electrical communication between the bridged die.

Therefore, it would be advantageous to develop a technique and assembly for increasing integrated circuit density using non-customized die configurations in combination with commercially-available, widely-practiced semiconductor device fabrication techniques.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus and a method for increasing integrated circuit density. The apparatus comprises at least an upper die and an opposing lower die which is connected to a substrate (the term "substrate" will be used for purposes of this application to mean either substrate carrying traces or other conductors, or a leadframe). The lower ^{die}die is preferably a flip chip having, for example, C4 solder bump connections, conductive polymer bumps, pin connections, or ~~a~~ surface mount J-lead connections extending substantially perpendicularly from the face surface of the lower die. The substrate is configured with a specific lead end or trace end pattern compatible with the specific pin out or bump connections on the flip-chip.

A layer of adhesive, in some instances an electrically insulative adhesive as required or desired to electrically isolate adjacent ^{die}die, is applied over the back side of the lower ^{die}die. The back side of the upper die is placed on the adhesive, thereby attaching the upper die to the lower die, and the adhesive is cured. Preferably, the face or active side of the upper die includes a plurality of bond pads. Bond wires of gold, aluminum or other suitable materials as known in the art are attached between the upper ^{die}die bond pads and a corresponding trace end or lead end on the substrate.

It is, of course, understood that the electrical connection between the upper die and the substrate can be achieved with TAB technology, wherein metal tape leads are attached between the bond pads on the upper die and the leads on the substrate.

However, such an approach obviously requires undesirable pre-planning of bond pad and trace end locations for fabrication of the TAB tape.

An encapsulant is generally used to cover the bond wires and metal tape leads to prevent contamination. Preferably, the exposed circuitry of the die stack is sealed from contamination by an underflow compound for the (lower) flip chip and a glob top over the entire assembly after wire bonding.

Such an arrangement increases semiconductor device density using non-customized die and bond pad patterns, and commercially-practiced conductor attachment techniques.

If the upper die is smaller than the lower die, one or more ^{small, additional,} ~~small additional~~ discrete components such as resistors, capacitors, or the like can be attached to the back side of the lower die via a portion of the adhesive not covered by the upper die. Bond wires can be attached between the upper die and the discrete component(s), if desired, as well as between the component(s) and the substrate. This arrangement frees up real estate on the substrate that would normally be taken up by the component, thereby further increasing potential integrated circuit density.

A multitude of die arrangements can be conceived using the technique of the present invention. For example, an additional (third) die can be added to the above arrangement. An adhesive is added to the active surface or face of the upper die (without covering the bond pads) and the back side of the additional die is applied to the adhesive, thereby attaching the additional die to the upper die. Preferably, the face side of the additional die has a plurality of bond pads. Bond wires are attached between the additional die bond pads and corresponding trace or lead ends on the substrate.

Of course, the bond wires can be attached from the additional (third) die to a component attached to the adhesive not covered by the upper die, and/or, if the additional die is smaller than the upper die, a component can be attached to the adhesive on the face of the upper die and bond wires attached thereto.

As another example, a pair of lower ^{dice} ~~die~~ can be connected to the substrate with the upper die bridged between the lower die. The upper die is adhered to both lower

^{dice}
~~die~~ with the layers of adhesive applied over both lower ^{dice}
~~die~~ back sides. Bond wires ^{dice}
are attached in the manner discussed above. Furthermore, still more additional ~~die~~ ^{dice}
can be stacked or discrete components attached to the assembly in the manner
discussed above.

5

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming that which is regarded as the present invention, the advantages of this invention can be more readily ascertained from the following description of the invention when read in conjunction with the accompanying drawings in which:

FIG. 1 is a side plan view of a preferred assembly of the present invention;

FIG. 2 is a side plan view of an alternate assembly of the present invention;

FIG. 3 is a side plan view of another alternate assembly of the present invention;

FIG. 4 is a side plan view of yet another alternative assembly of the present invention; and

FIG. 5 is a side plan view of still another alternative assembly of the present invention.

BEST MODE OF THE INVENTION

FIG. 1 illustrates a bare die assembly 10 of the present invention. The assembly 10 comprises an upper die 12 and an opposing lower die 14 which is connected to a leadframe or other substrate 16. Fabrication of the assembly 10 comprises providing the lower die 14 having a face surface 18 with at least one flip chip electric connection 20 (such as a C4 solder bump connection, conductive polymer bump or pin connection, these and other alternatives being known in the art, by way of example) extending from a bond pad or other terminal 22 on the lower die face surface 18. The flip chip electric connections 20 extend to a surface 24 of the substrate 16 in such a manner that the flip chip electric connections 20 physically (mechanically) attach to, and make electrical contact with, lead ends, trace ends,

terminals or other electrical contact elements 26 in or on the surface 24 of the substrate 16. A back side 32 of the upper die 12 is adhered to the lower die 14 with a layer of adhesive 28 applied over a lower die back side 30. An adhesive requiring a curing step, such as an epoxy, is preferred, although many adhesives known in the art are suitable.

A face side 34 of the upper die 12 has a plurality of bond pads 36 disposed thereon. A plurality of bond wires 38 are attached between the upper die bond pads 36 and corresponding trace or lead ends or other terminals 40 on the upper surface 24 of the substrate 16.

Preferably, a sealing (underfill) compound 42 as known in the art is disposed between the lower die 14 and the substrate 16 to prevent contamination of the die-to-substrate board connections 20 and to more firmly secure the lower die 14 to the substrate 16. A glob top 48 may be applied over assembly 10 individually as shown in broken lines, or over the entire substrate 16, which may support a plurality of assemblies 10. The subsequently-described embodiments may similarly be glob-topped, as desired.

Substrate 16, if an insulative substrate, may itself be connected to a chassis or mother board by edge connections, bump connections, pin connections, or other conductive arrangements as known in the art. If substrate 16 is a lead frame, the outer lead ends may engage a higher-level package as known in the art.

FIG. 2 illustrates an alternative bare die assembly 50 of the present invention. Components common to both FIG. 1 and FIG. 2 retain the same numeric designation. The assembly 50 comprises a first, lower die 14 connected to the supporting substrate or leadframe 16. The lower die 14 comprises a face or active surface 18 with at least one flip chip electric connection 20 extending from the bond pad 22 on the lower die face surface 18. The flip chip electric connections 20 are made with the upper surface 24 of the substrate 16 in such a manner that the flip chip electric connections 20 mechanically bond and electrically contact the electrical contact elements 26 in or on the surface 24 of the substrate 16.

A back side 52 of a second die 54 is adhered to the lower die 14 with the layer of adhesive 28 applied over the lower die back side 30. A face side 56 of the second die 54 has a plurality of bond pads 58 disposed thereon. A plurality of bond wires 60 ^{is} ~~are~~ attached between the second die bond pads 58 and corresponding trace or lead ends 40 on the upper surface 24 of the substrate 16. Additionally, as shown in FIG. 2, if the second die 54 is slightly smaller than the lower die 14, an additional component 62, such as a resistor, capacitor, or the like, may be adhered to the layer of adhesive 28 on the lower die back side 30. This arrangement frees up space on the substrate 16 that would normally be taken up by the component 62. A second die-to-component ~~62~~ bond wire 64 is attached between a respective second die bond pad 58 and the component 62. A component-to-substrate bond wire 66 is attached between the component 62 and trace or lead end 40 on the upper surface 24 of the substrate 16.

A back side 68 of a third die 70 is adhered to the ~~first~~ ^{second} die 54 with a second layer of adhesive 72 applied on the second die face side 56. A face side 74 of the third die 70 has a plurality of bond pads 76 disposed thereon. A plurality of bond wires 78 ^{is} ~~are~~ attached between the third die bond pads 76 and corresponding trace lead ends 40 on the upper surface 24 of the substrate 16. Wire bonds could also be made from third die 70 to component 62, or to yet another discrete component stacked on and adhered to third die 70.

FIG. 3 illustrates another alternative bare die assembly 80, comprising a second discrete component 82 adhered to the second layer of adhesive 72. A third die-to-component bond wire 84 is attached between a respective third die bond pad 76 and the component 62. A first component-to-substrate bond wire 66 is attached between the component 62 ^{and} ~~to~~ the upper surface 24 of the substrate 16. A third die-to-second component bond wire 86 is attached between a respective second die bond pad 76 and the second component 82. A second component-to-substrate bond wire 88 is attached between the component 82 and the upper surface 24 of the substrate 16.

It is, of course, understood that a number of configurations of this embodiment could be constructed, including stacks of more than three ^{dice} ~~die~~.

FIG. 4 illustrates a multiple base bare die assembly 90 of the present invention. Components common to the previous figures retain the same numeric designation. The assembly 90 comprises a pair of lower first ^{dice} die 14A and 14B connected to the substrate or leadframe 16. The lower ^{dice} die 14A and 14B comprise face surfaces 18A and 18B, each having at least one flip chip electric connection 20A and 20B extending substantially perpendicularly from the bond pads 22A and 22B on the lower die face surfaces 18A and 18B. The flip chip electric connections 20A and 20B extend to the upper surface 24 of the substrate 16 in such a manner that the flip chip electric connections 20A and 20B make physical connection and electrical contact with the electrical contact elements 26 in or on the surface 24 of the substrate 16.

The back side 52 of second die 54 bridges and is adhered to both lower ^{dice} die 14 with the layers of adhesive 28A and 28B applied over the lower die back sides 30A and 30B. The face side 56 of the second die 54 has a plurality of bond pads 58 disposed thereon. A plurality of bond wires 60 ^{is} are attached between the second die bond pads 58 and corresponding trace or lead ends 40 on the upper surface 24 of the substrate 16. Additional components 62A and 62B, such as resistors, capacitors, or the like, may be adhered to the layers of adhesive 28A and 28B on the lower die back sides 30A and 30B. This arrangement frees up space on the substrate 16 that would normally be taken up by the components 62A and 62B. A second die-to-component bond wire 92 is attached between a respective first die bond pad 58 and the component 62B. A first component-to-substrate bond wire 94 is attached between the component 62B and the upper surface 24 of the substrate 16.

The back side 68 of the third die 70 is adhered to the second die 54 with the second layer of adhesive 72 applied on the second die face side 56. The face side 74 of the third die 70 has a plurality of bond pads 76 disposed thereon. A plurality of bond wires 78 ^{is} are attached between the third die bond pads 76 and corresponding trace or lead ends 40 on the upper surface 24 of the substrate 16. A third die-to-component bond wire 96 is attached between a respective third die bond pad 76 and the component 62A. A second component-to-substrate bond wire 98 is attached between the component 62A to the upper surface 24 of the substrate 16.

FIG. 5 illustrates a second multiple base bare die assembly 100 of the present invention. Components common to the previous figures retain the same numeric designation. The assembly 100 comprises a pair of lower first ^{dice} ~~die~~ 14A and 14B connected to the substrate or leadframe 16. The lower ^{dice} ~~die~~ 14A and 14B comprise face surfaces 18A and 18B, each having at least one flip chip electric connection 20A and 20B extending substantially perpendicularly from the bond pads 22A and 22B on the lower die face surfaces 18A and 18B. The flip chip electric connections 20A and 20B extend to the upper surface 24 of the substrate 16 in such a manner that the flip chip electric connections 20A and 20B make physical connection and electrical contact with the electrical contact elements 26 in or on the surface 24 of the substrate 16.

The back side 52 of second die 54 bridges and is adhered to both lower ^{dice 14A and 14B} ~~die 14~~ with the layers of adhesive 28A and 28B applied over the lower die back sides 30A and 30B. The face side 56 of the second die 54 has a plurality of bond pads 58 disposed thereon. A plurality of bond wires 60 ^{is} ~~are~~ attached between the second die bond pads 58 and corresponding trace or lead ends 40 on the upper surface 24 of the substrate 16. An additional component 62, such as a resistor, capacitor, or the like, may be adhered to substrate or leadframe 16 by a layer of adhesive 64. A second die-to-component bond wire 92 is attached between a respective first die bond pad 58 and the component 62. A component-to-substrate bond wire 94 is attached between the component 62 and the upper surface 24 of the substrate 16.

It is, of course, understood that a number of configurations of this embodiment could be constructed. For example, multiple bridge ^{dice} ~~die~~ may be employed over multiple lower ^{dice} ~~die~~; more than three levels of ^{dice} ~~die~~ could be stacked; rectangular ^{dice} ~~die~~ may be stacked with their major axes mutually perpendicular; a conductive die attach adhesive may be employed between a flipped base die and an upper stack die so that both ^{dice} ~~die~~ may be grounded through the upper ^{dice's} ~~die's~~ wire bonds to the substrate; bond pad layouts may be varied, and the like.

Having thus described in detail preferred embodiments of the present invention, it is to be understood that the invention defined by the appended claims is not to be limited by particular details set forth in the above description, as many

CLAIMS

What is claimed is:

1. A bare semiconductor die assembly including a plurality of semiconductor die, comprising:
a substrate including a plurality of conductors;
at least one active face-down base die in electrical communication with at least one
5 conductor;
at least one active face-up stack die attached back-to-back to said base die; and
means for electrically connecting said stack die to at least one conductor.
2. The assembly of claim 1, wherein said stack die includes at least one
10 bond pad.
3. The assembly of claim 2, wherein said means for electrically connecting said stack die to said at least one conductor is a bond wire extending between said at least one bond pad and said at least one conductor.
- 15 4. The assembly of claim 1, further comprising a first adhesive interposed between said base die and said stack die.
5. The assembly of claim 4, further comprising at least one discrete
20 component adhered to said first adhesive, and a die-to-component bond wire electrically connecting said stack die to said component.
6. The assembly of claim 4, further comprising at least one discrete
component adhered to said first adhesive, and a component-to-substrate bond wire
25 electrically connecting said stack die to a substrate conductor.
7. The assembly of claim 1, further comprising a second stack die and means for electrically connecting said second stack die to a substrate conductor.

8. The assembly of claim 7, wherein said second stack die includes at least one bond pad.

9. The assembly of claim 8, wherein said means for electrically connecting said second stack die to said substrate conductor is a bond wire extending between said at least one bond pad and said at least one conductor.

10. The assembly of claim 7, wherein said second stack die is attached to said stack die.

11. The assembly of claim 10, further comprising a second adhesive interposed between said second stack die and said stack die.

12. The assembly of claim 11, further comprising at least one discrete component adhered to said second adhesive, and a die-to-component bond wire connecting said second stack die to said component.

13. The assembly of claim 11, further comprising at least one discrete component adhered to said second adhesive, and a component-to-substrate bond wire connecting said component to a substrate conductor.

14. The assembly of claim 10, further comprising at least one discrete component adhered to said first adhesive, a die-to-component bond wire connecting said second stack die to said component, and a component-to-substrate bond wire connecting said component to a substrate conductor.

15. The assembly of claim 1, further comprising a second active face-down base die in electrical communication with a substrate.

16. The assembly of claim 15, wherein at least one said stack die bridges said base die and second base die.

5 17. The assembly of claim 16, further including at least one discrete component secured to said substrate, and a component-to-substrate bond wire electrically connecting said stack die to said component.

10 18. The assembly of claim 1, further including at least one discrete component secured to said substrate, and a component-to-substrate bond wire electrically connecting said stack die to said component.

15 *Sub a¹* 19. A method of fabricating a multi-die assembly, comprising:
providing a substrate including a plurality of conductors;
attaching at least one active face-down base die to said substrate in electrical communication with at least some of said conductors;
securing the back side of at least one active face-up stack die to said base die; and
electrically connecting said stack die to at least one of said conductors.

20 20. The method of claim 19, wherein said electrically connecting said at least one stack die to said at least one conductor comprises wire bonding.

25 *Sub a²* 21. The method of claim 19, further comprising:
securing at least one discrete component to said base die; and
extending a die-to-component bond wire between said at least one stack die and said component.

30 22. The method of claim 19, further comprising:
securing at least one discrete component to said base die; and
extending a component-to-substrate bond wire between said component and a substrate conductor.

Sub A²
23. The method of claim 19, further comprising:
securing a second stack die to said assembly; and
electrically connecting said second stack die and at least one substrate conductor.

5 24. The method of claim 23, wherein electrically connecting said second stack die to said at least one conductor comprises wire bonding.

Sub C³
10 25. The method of claim 23, further comprising securing said second stack die to said stack die.

Sub A³
15 26. The method of claim 25, further comprising:
securing at least one discrete component to said stack die; and
extending a die-to-component bond wire between said second stack die and said component.

20 27. The method of claim 26, further comprising:
securing at least one discrete component to said stack die; and
extending a component-to-substrate bond wire between said component and a substrate conductor.

25 28. The method of claim 25, further comprising:
securing at least one discrete component to said base die; and
extending a die-to-component bond wire between said second stack die and said component.

30 29. The method of claim 25, further comprising:
securing at least one discrete component to said base die; and
extending a component-to-substrate bond wire between said component and a conductor.

Sub a³ → 30. The method of claim 19, further comprising attaching a second active face-down base die to said substrate in electrical communication with at least one of said conductors.

5 mbc3 → 31. The method of claim 30, further comprising bridging said stack die between said base die and second base die.

32. The method of claim 31, further comprising securing a second stack die over said stack die.

Sub a⁴ → 33. The method of claim 19, further comprising:
securing at least one discrete component to said substrate; and
extending a die-to-component bond wire between said at least one stack die and said component.

34. The method of claim 31, further comprising:
securing at least one discrete component to said substrate; and
extending a die-to-component bond wire between said at least one stack die and said component.

08-602503

ABSTRACT

5 An apparatus and method for increasing integrated circuit density comprising
an upper die and a lower die, the latter preferably a flip-chip, which are connected to
a conductor-carrying substrate or a leadframe. The upper die is attached back-to-back
to the lower die with a layer of adhesive applied over the back side of the lower
die. Bond wires or TAB leads are attached between bond pads on the upper die and
corresponding conductive trace or lead ends on the substrate. The upper die may be
smaller than the lower die such that a small discrete component such as a resistor,
capacitor, or the like can be attached to the adhesive not covered by the upper die.
10 Bond wires can be attached between the upper die and the component, as well as
between the component and the substrate. One or more additional die may be stacked
on the upper die and electrically connected to the substrate. Furthermore, multiple
lower dice can be arranged on the substrate to support upper dice bridged between the
lower dice.

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FIG. 1

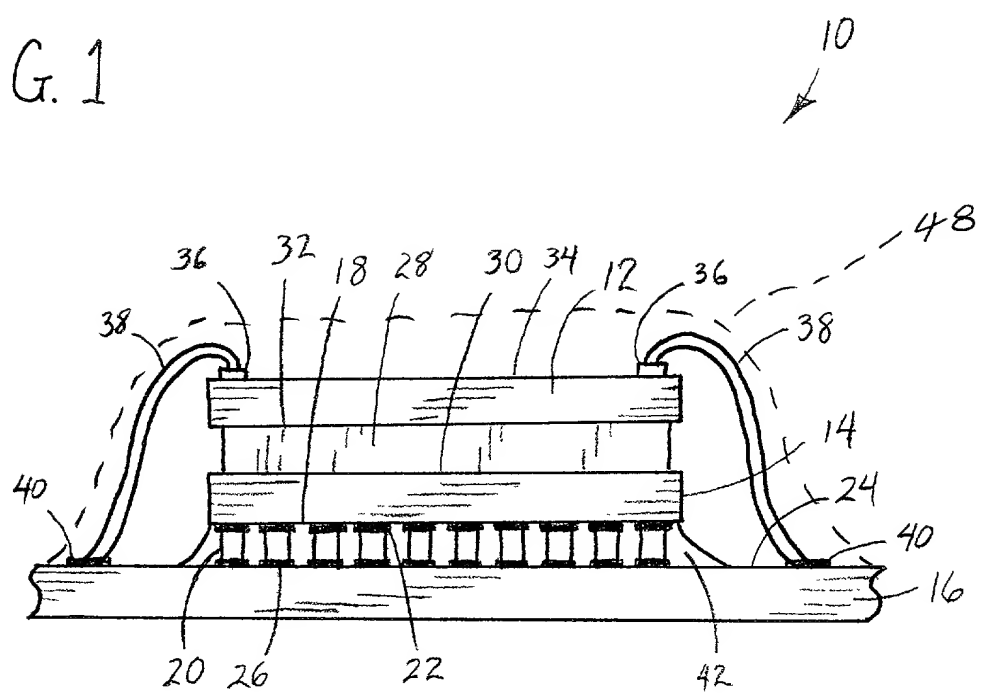
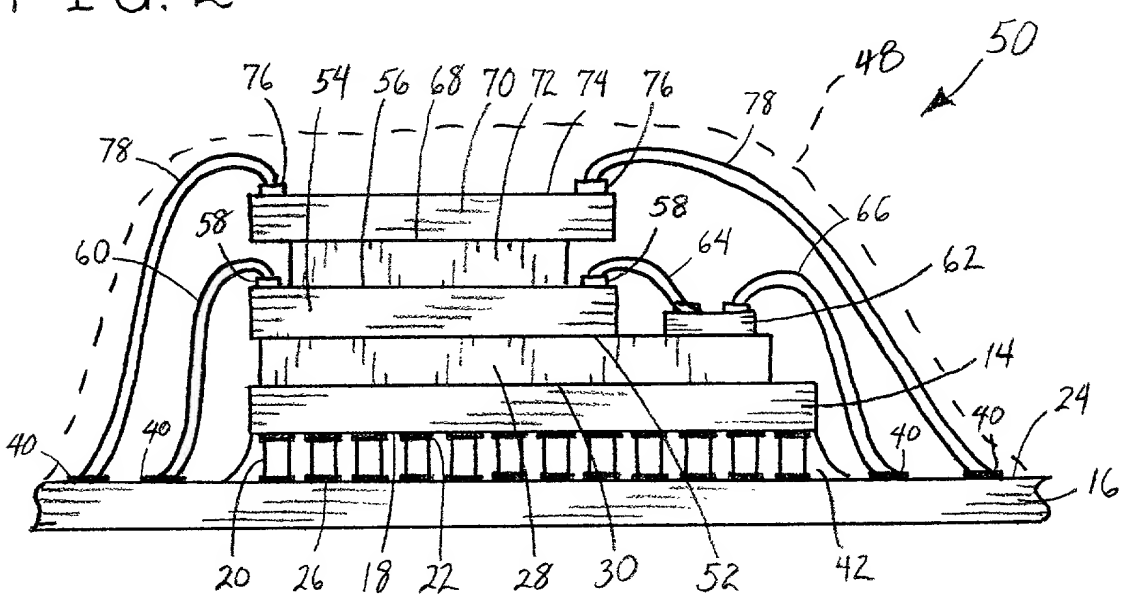
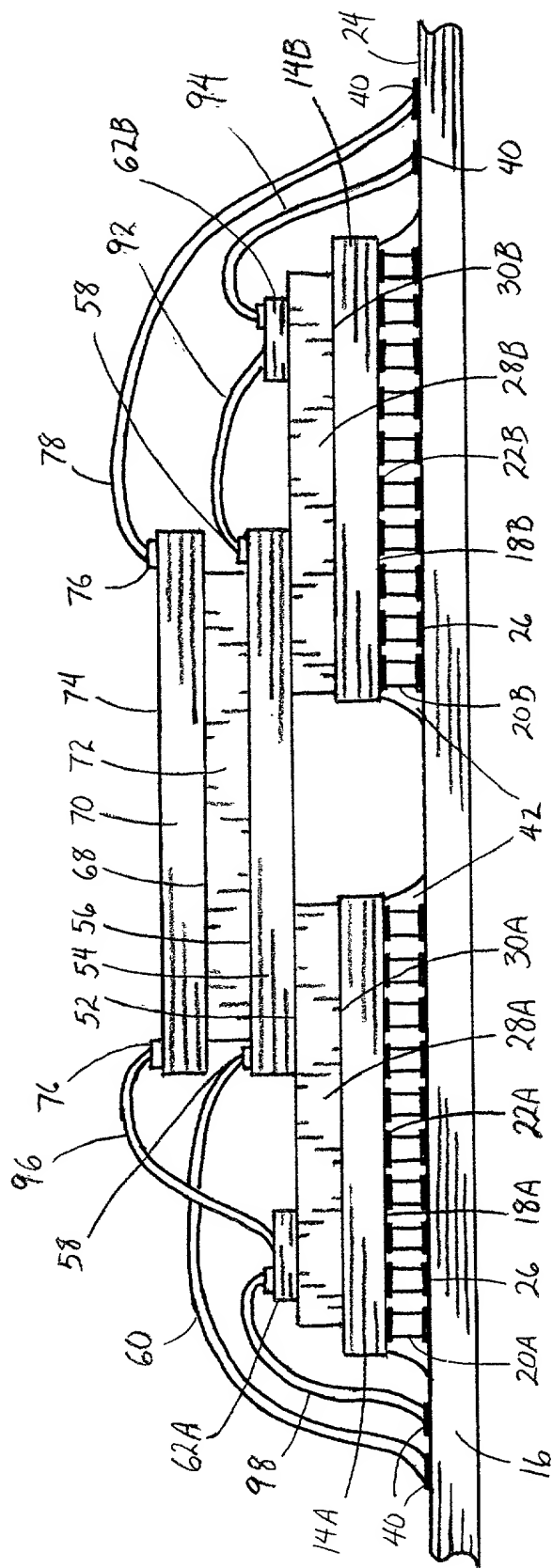


FIG. 2



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DECLARATION FOR PATENT APPLICATION (WITH POWER OF ATTORNEY)

08-602583

As an inventor named below or on any attached continuation page, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled FLIP CHIP AND CONVENTIONAL STACK, the specification of which (check one):

☒ is attached hereto.

☐ was filed on _____ as United States application serial no. _____ and was amended on _____.

☐ was filed on _____ as PCT international application no. _____ and was amended under PCT Article 19 on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and on any attached continuation page and have also identified below and on any attached continuation page any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America having a filing date before that of the application(s) on which priority is claimed.

Prior foreign/PCT application(s):

Priority Claimed

(number)	(country)	(day/month/year filed)	Yes	No
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America listed below and on any attached continuation page and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

(application serial no.)	(filing date)	(status - pending, patented or abandoned)
_____	_____	_____
_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

(provisional application no.)	(filing date)
_____	_____
_____	_____
_____	_____

I hereby appoint the following Registered Practitioners to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole inventor: Michael B. Ball

Inventor's signature: Michael B. Ball Date: 2/14/96

Residence: Boise, Idaho

Citizenship: U.S.A.

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